The California Coast:
Shoreline Change over the Next Century

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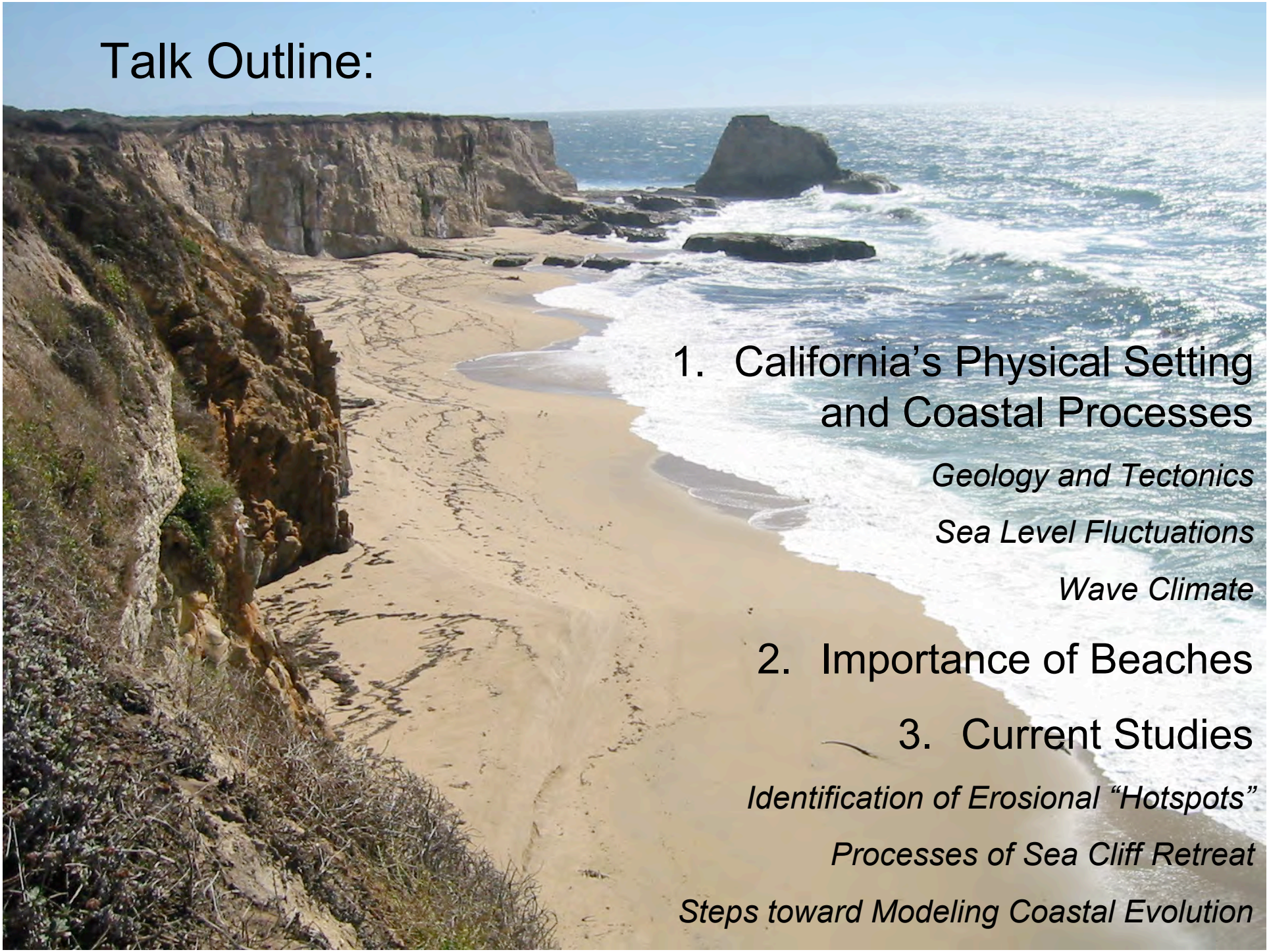
In collaboration with The Kavli Institute

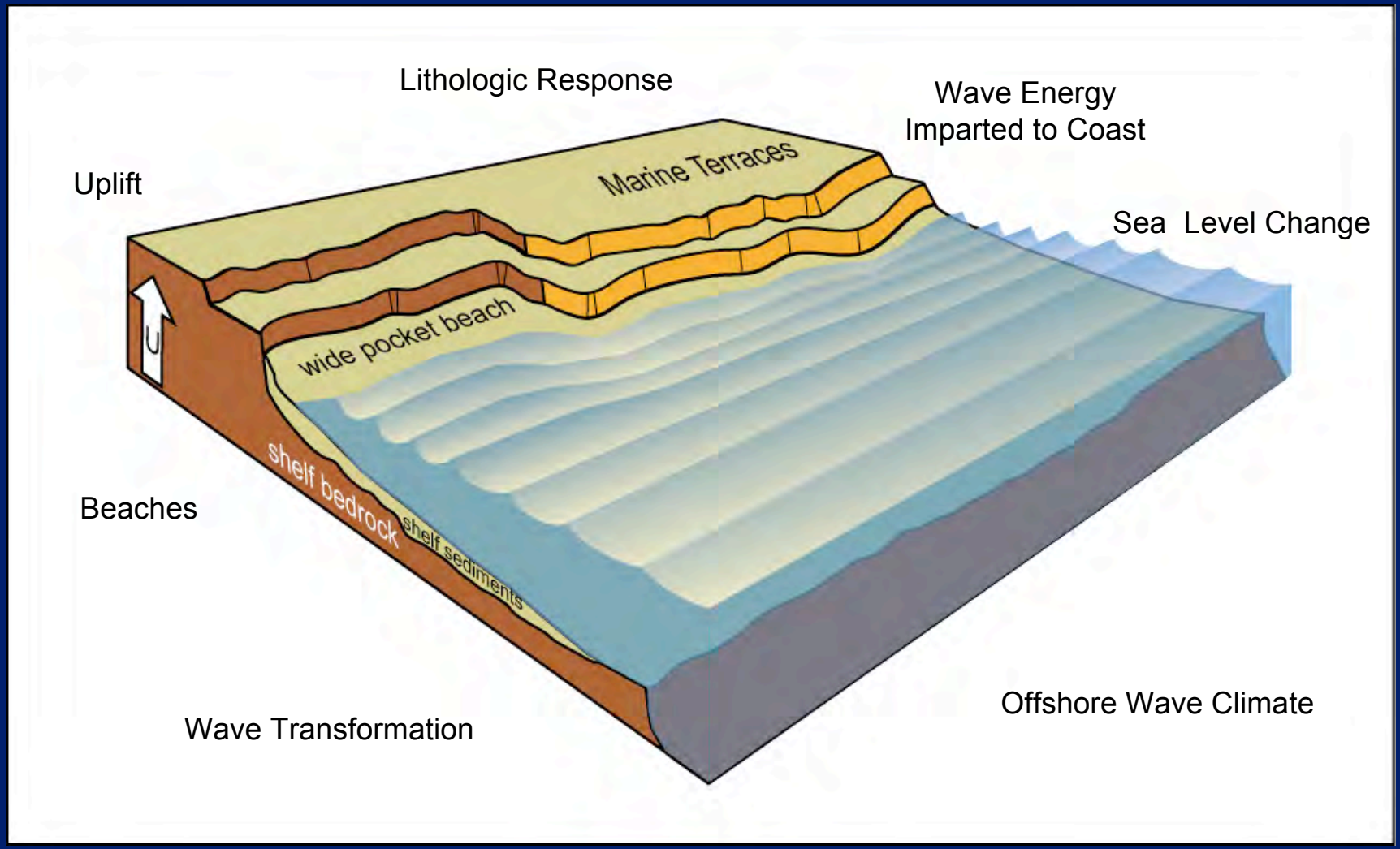
San Elijo State Beach March 2004

Talk Outline:

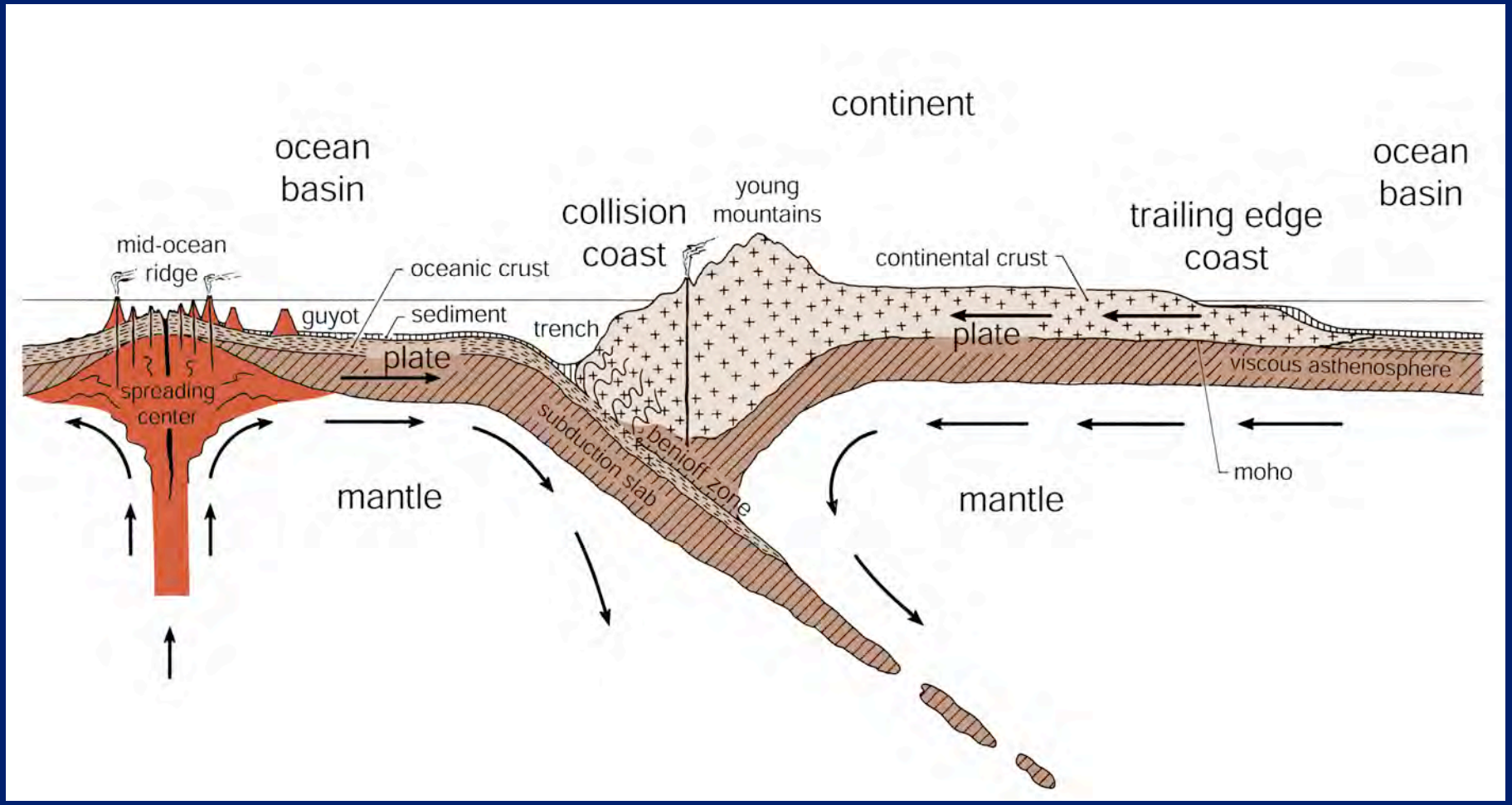


1. California's Physical Setting and Coastal Processes
   - *Geology and Tectonics*
   - *Sea Level Fluctuations*
   - *Wave Climate*
2. Importance of Beaches
3. Current Studies
   - *Identification of Erosional "Hotspots"*
   - *Processes of Sea Cliff Retreat*
   - *Steps toward Modeling Coastal Evolution*

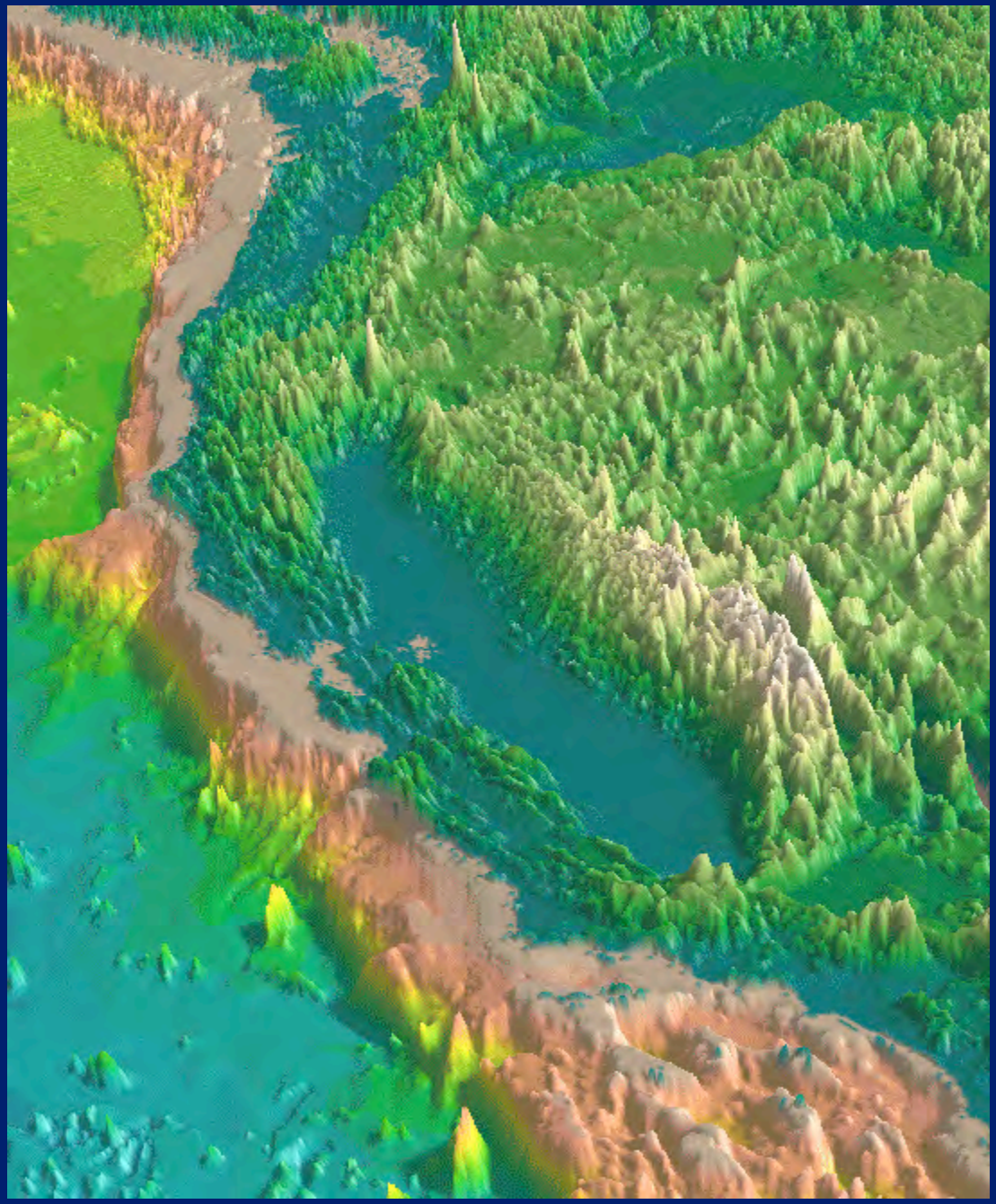
Overview of the California Coast - The Big Picture



Geologic Setting



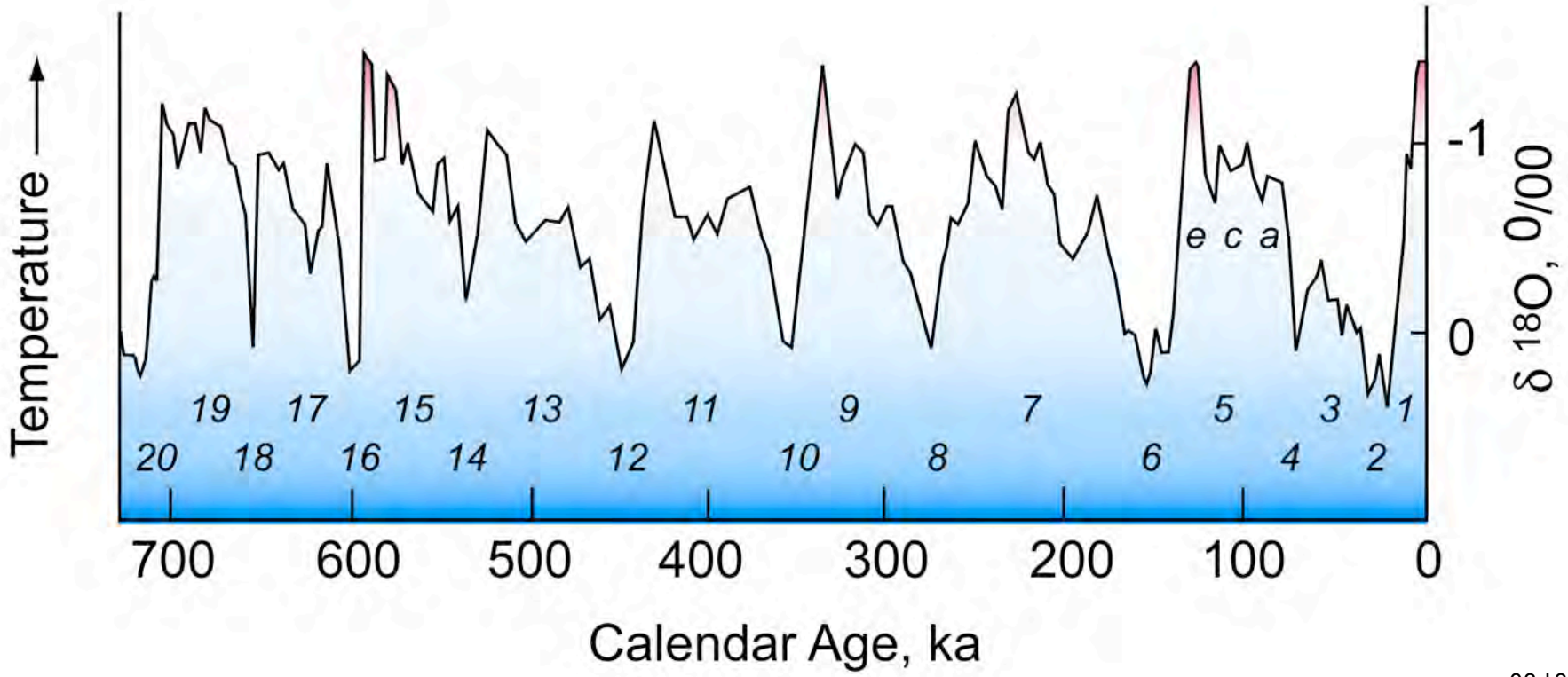
Tectonic Setting



Oblique view of
DEM data, California

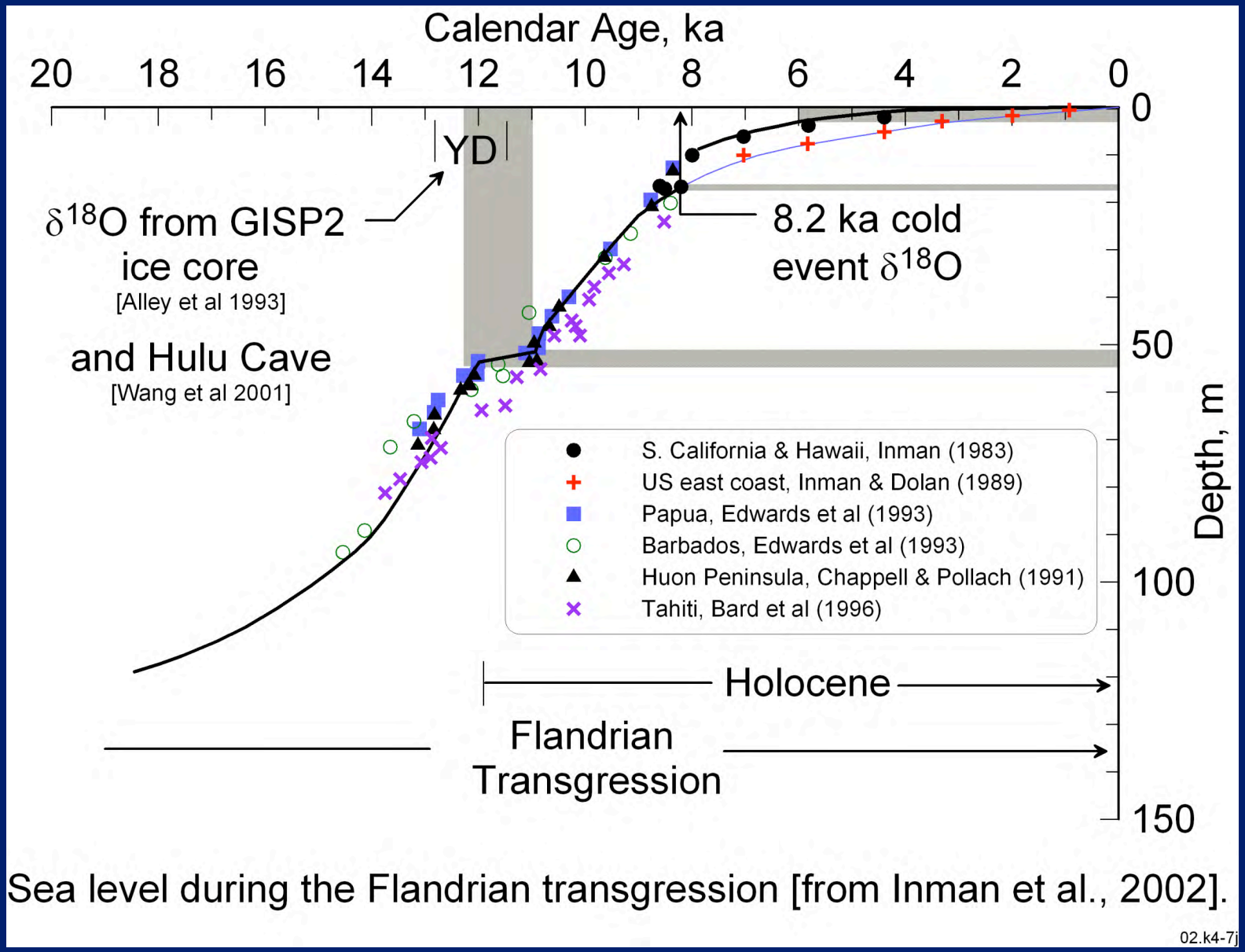
Image from Satellite Geodesy Group, Scripps Inst. of Oceanography

Long Term Sea Level Change



Generalized paleotemperature curve with oxygen isotope stages as a proxy for Pleistocene sea level [after Emiliani and Shackleton, 1974].

Recent Sea Level Change



Sea level during the Flandrian transgression [from Inman et al., 2002].

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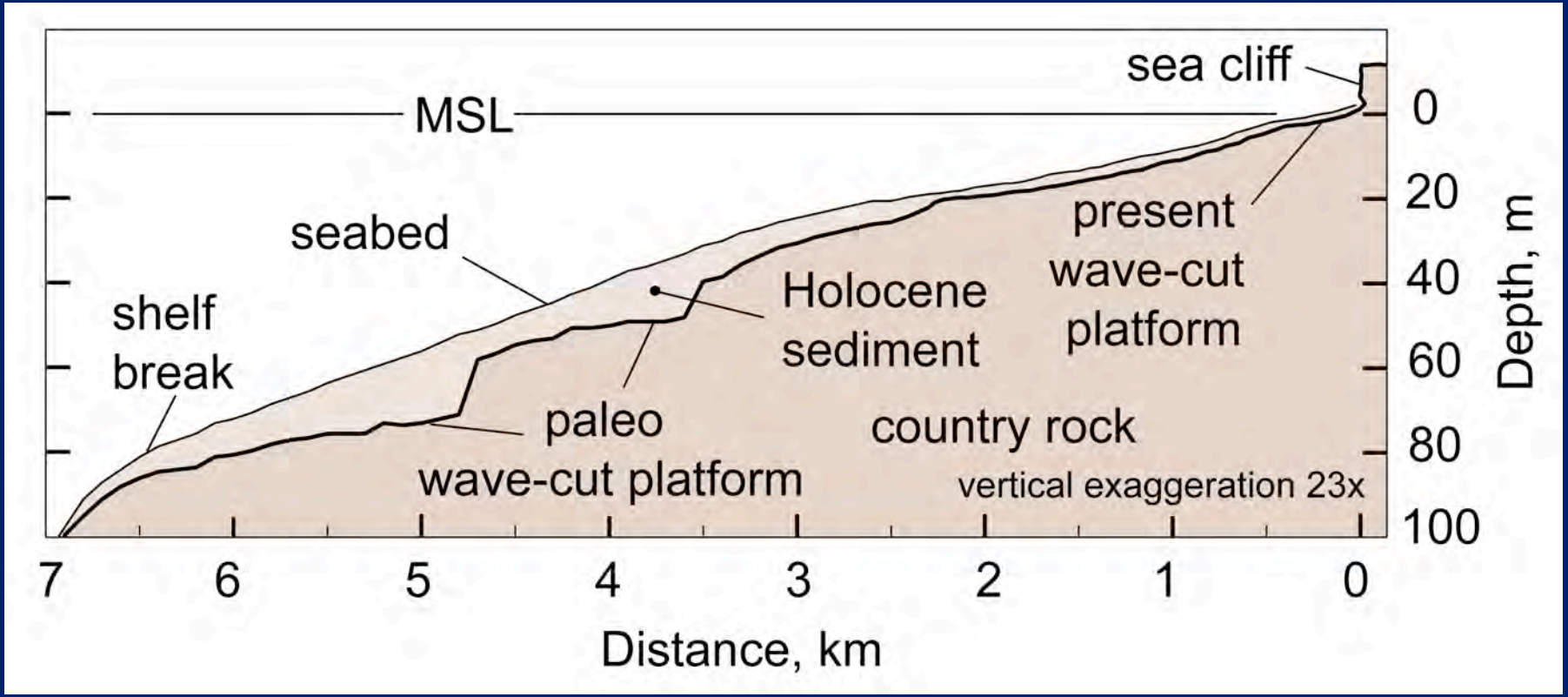
Marine Terraces -
Record History of Sea Level Change and Uplift

Highway 1 near Santa Cruz, California

Generalized Coastal Profile



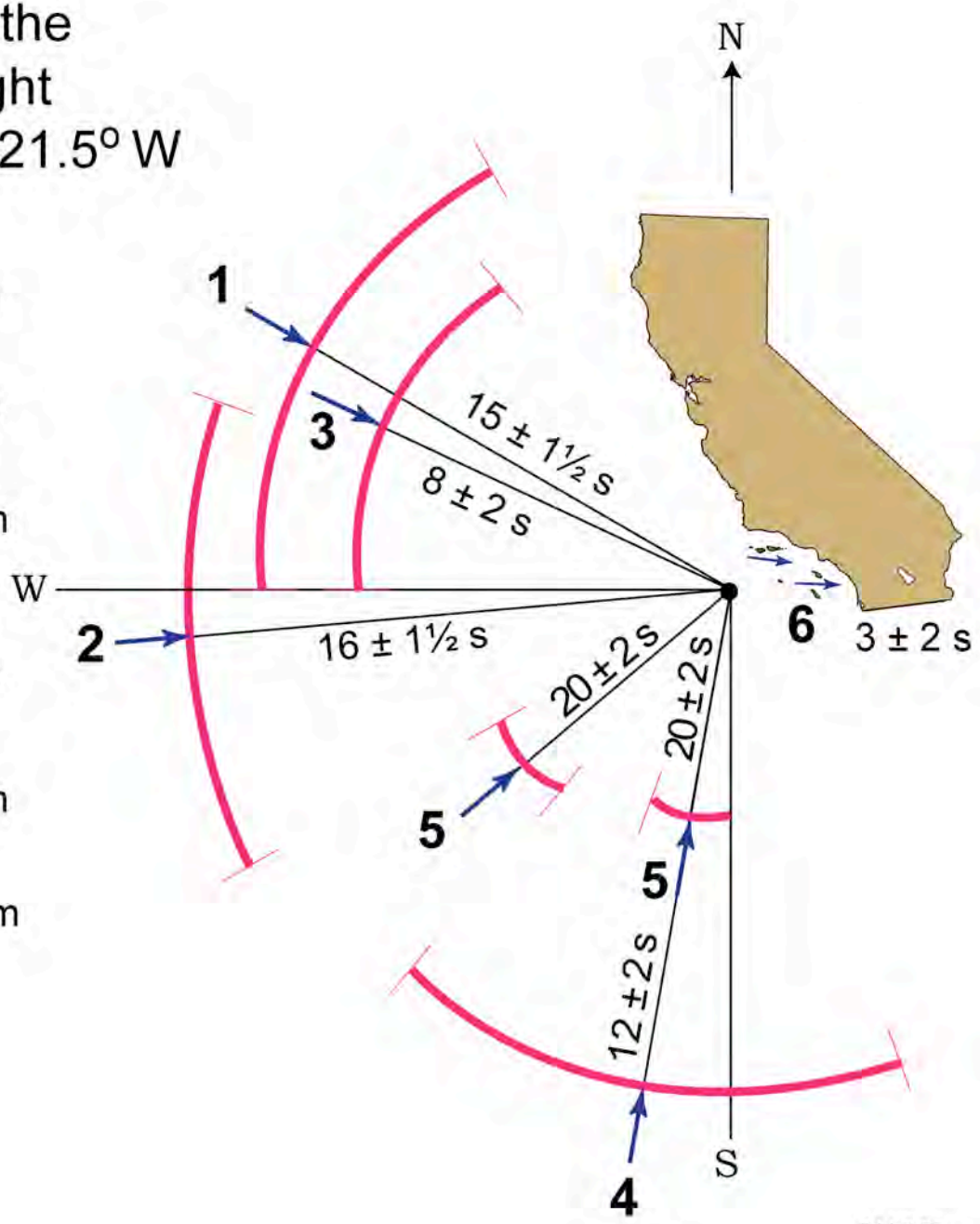
Wave Energy - The Forcing for Coastal Change

West cliff drive, Santa Cruz

Characteristic Waves of the Southern California Bight
Deep Water Station 33° N, 121.5° W

	H_s
1. Aleutian low. (winter, cool/dry)[a]	4 ± 2 m
2. Pineapple express (winter, warm/wet)[a]	5 ± 2 m
3. North Pacific high (mostly summer, stronger cool/dry)[a]	1 ± ½ m
4. Tropical storm (summer/fall, warm/wet)[a]	3 ± 2 m
5. S. hemisphere swell[b] (summer/fall, cool/dry)[a]	1 ± ½ m
6. Sea breeze[c] (summer/fall)	¾ ± ½ m

[a] (season, decadal climate cycle).
[b] Via Tasman Sea.
[c] Generated near the coast by land heating, direction ± 45° from shore normal with highest waves in the northern quadrant in the afternoon.



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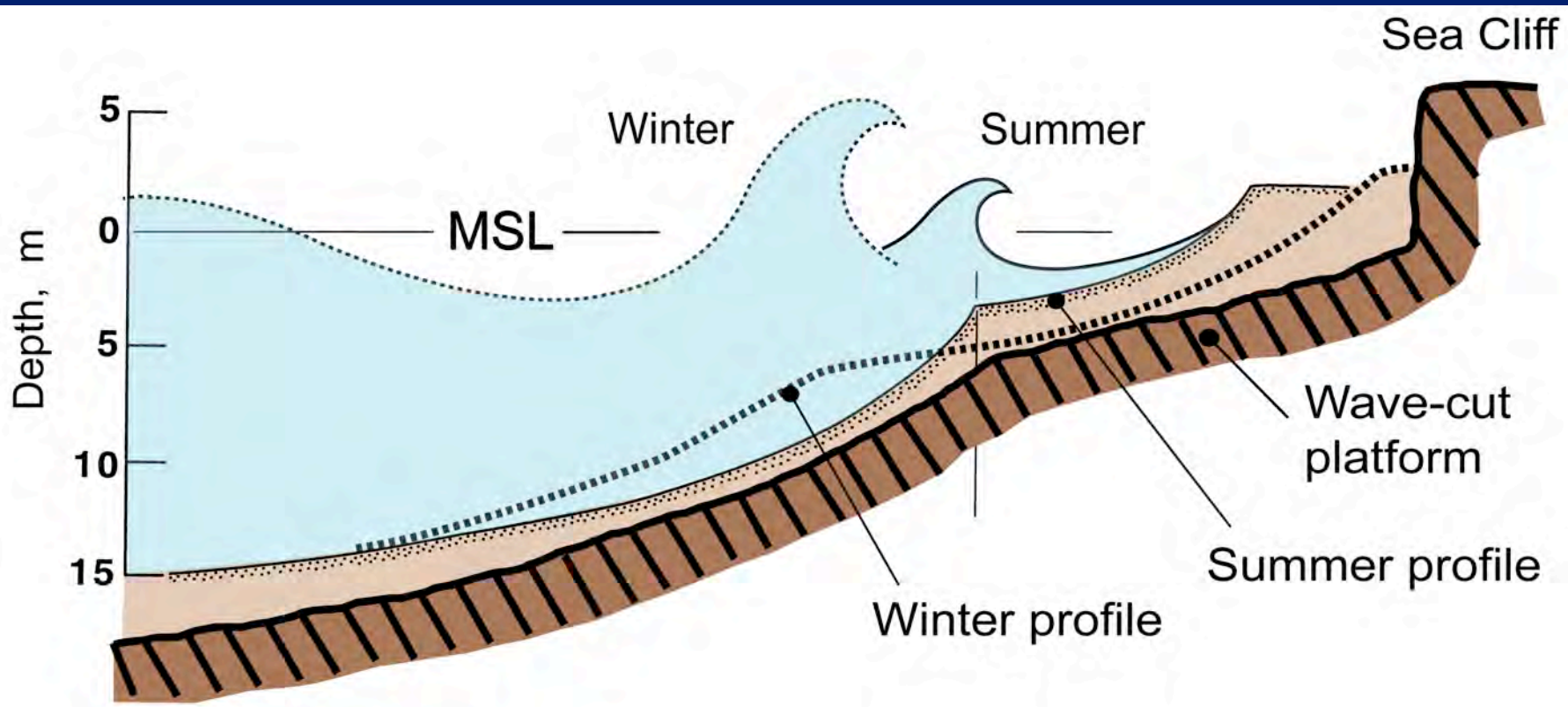
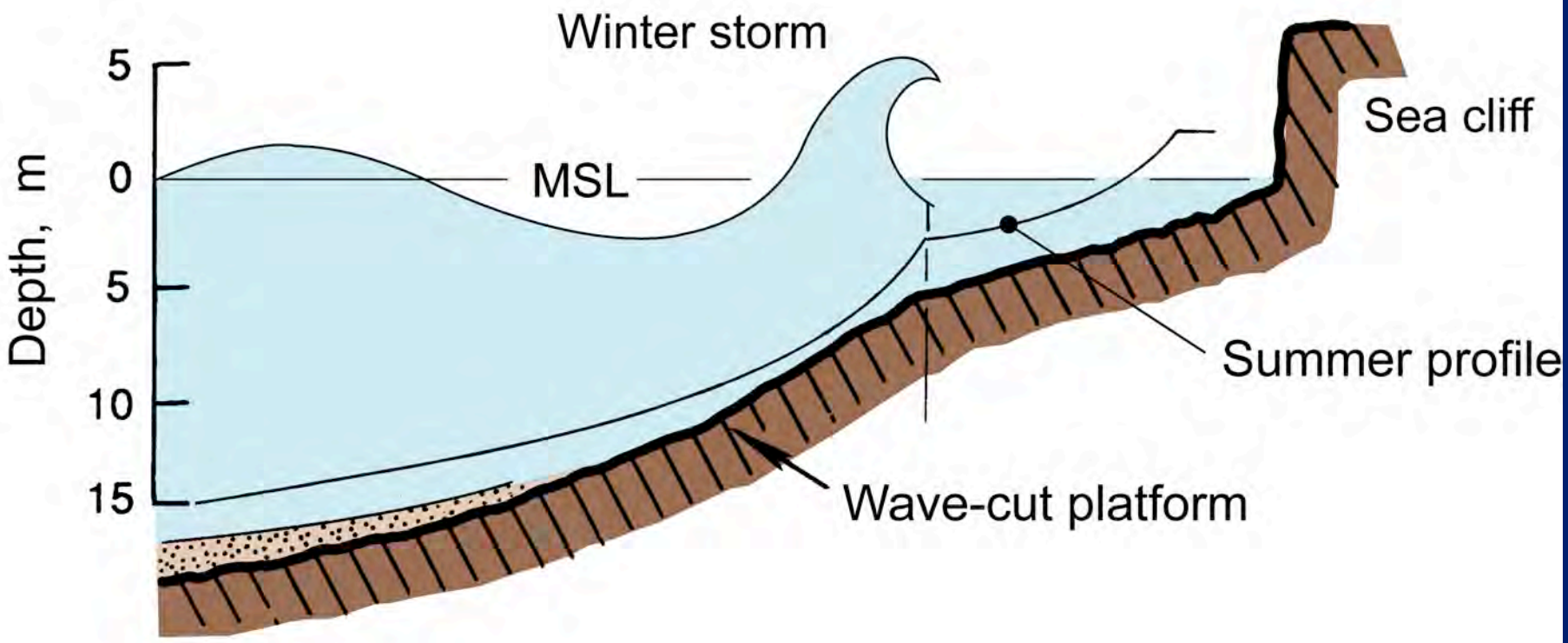
Seasonality of California Beaches



Seasonal Equilibrium Profiles (summer/winter waves)

Sediment Starved Case



Disequilibrium Profile (storm waves)

[after Inman, et al., 1993]

Basal Cliff Notching

Solana Beach January 2003

Sea Cliff Retreat – Processes and Timing

1. Abrasion of a Basal Notch
2. Thresholded Failure
3. Comminution Lag - Protective Feedback

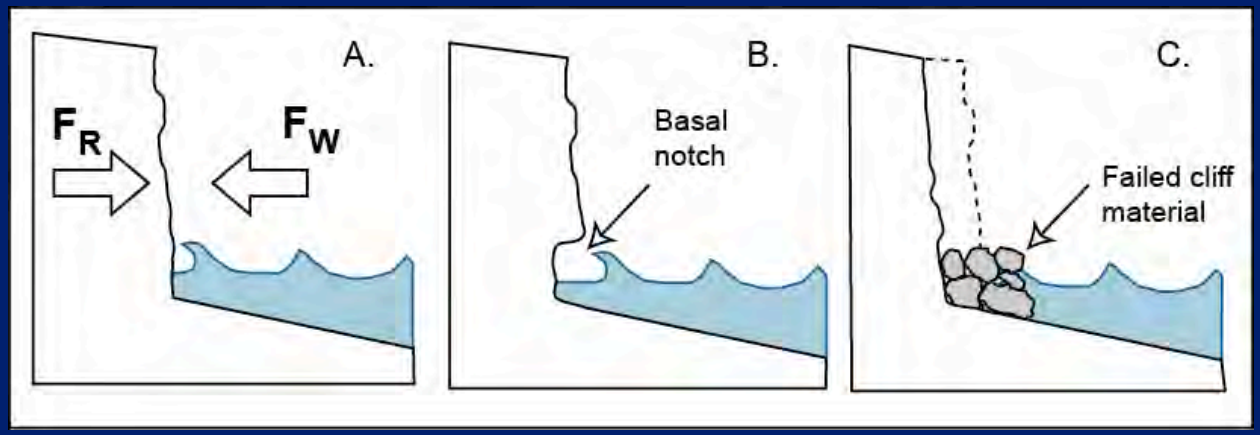
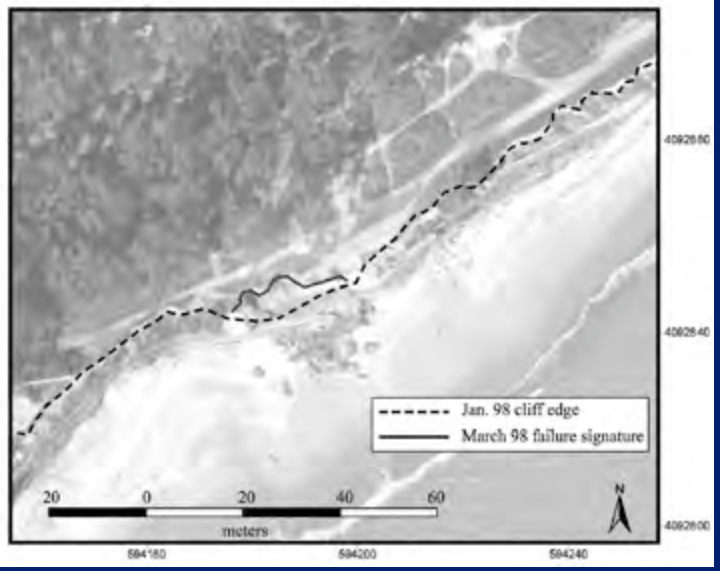
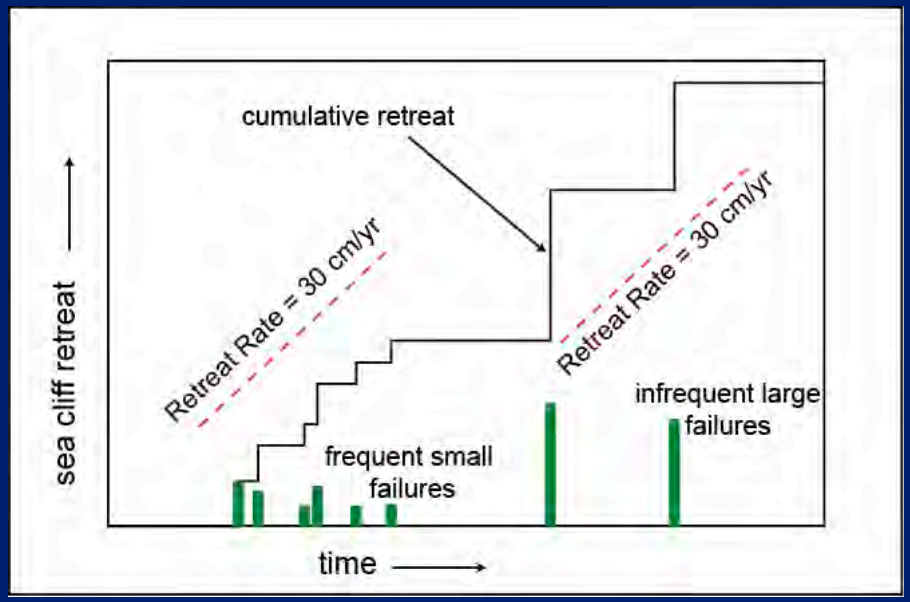


Figure from Hapke and Richmond, 2002, *Marine Geology*



Episodic Sea Cliff Failure



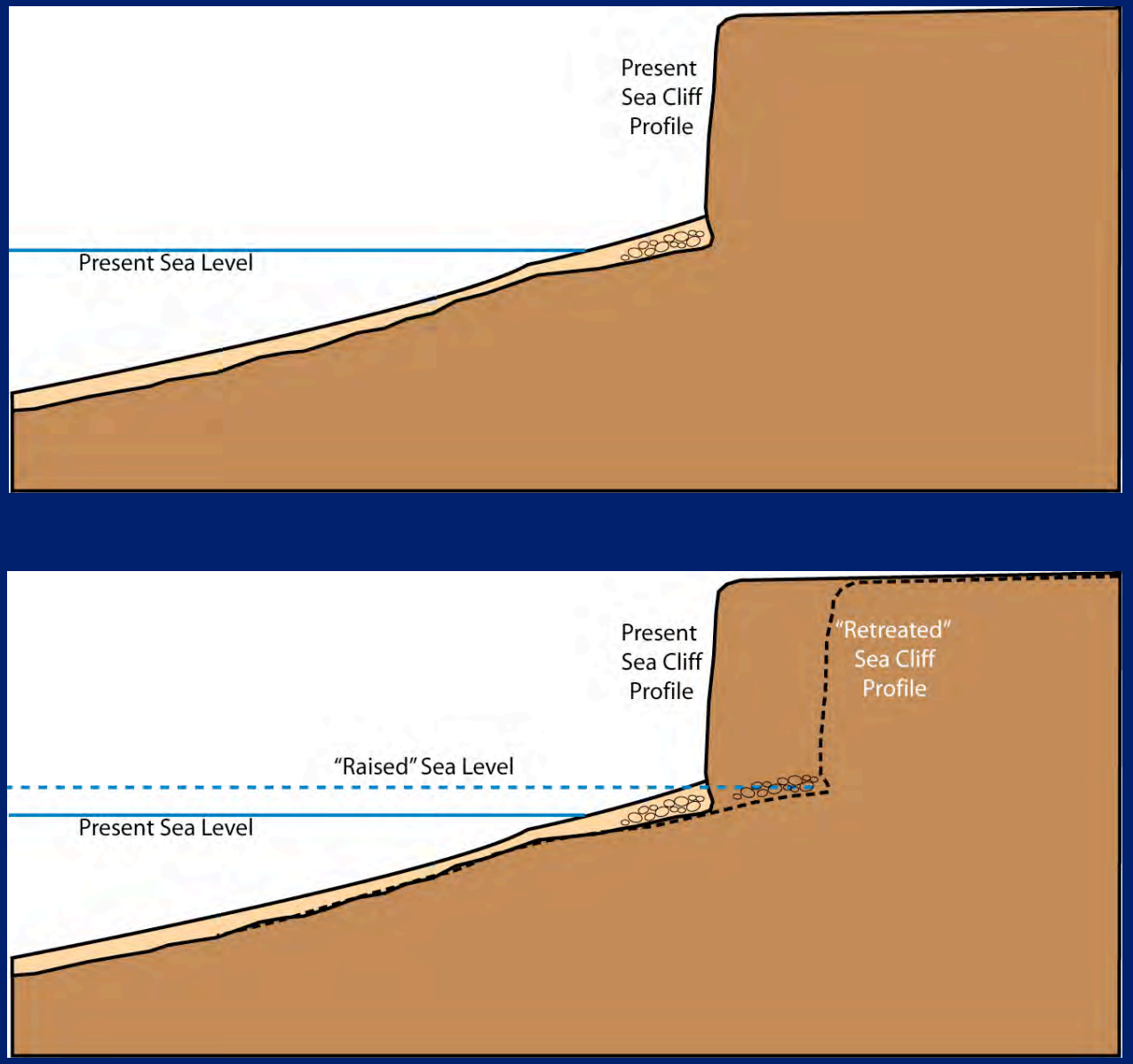
Retreat History

Implications of Climate Change and Sea Level Rise for California Coast

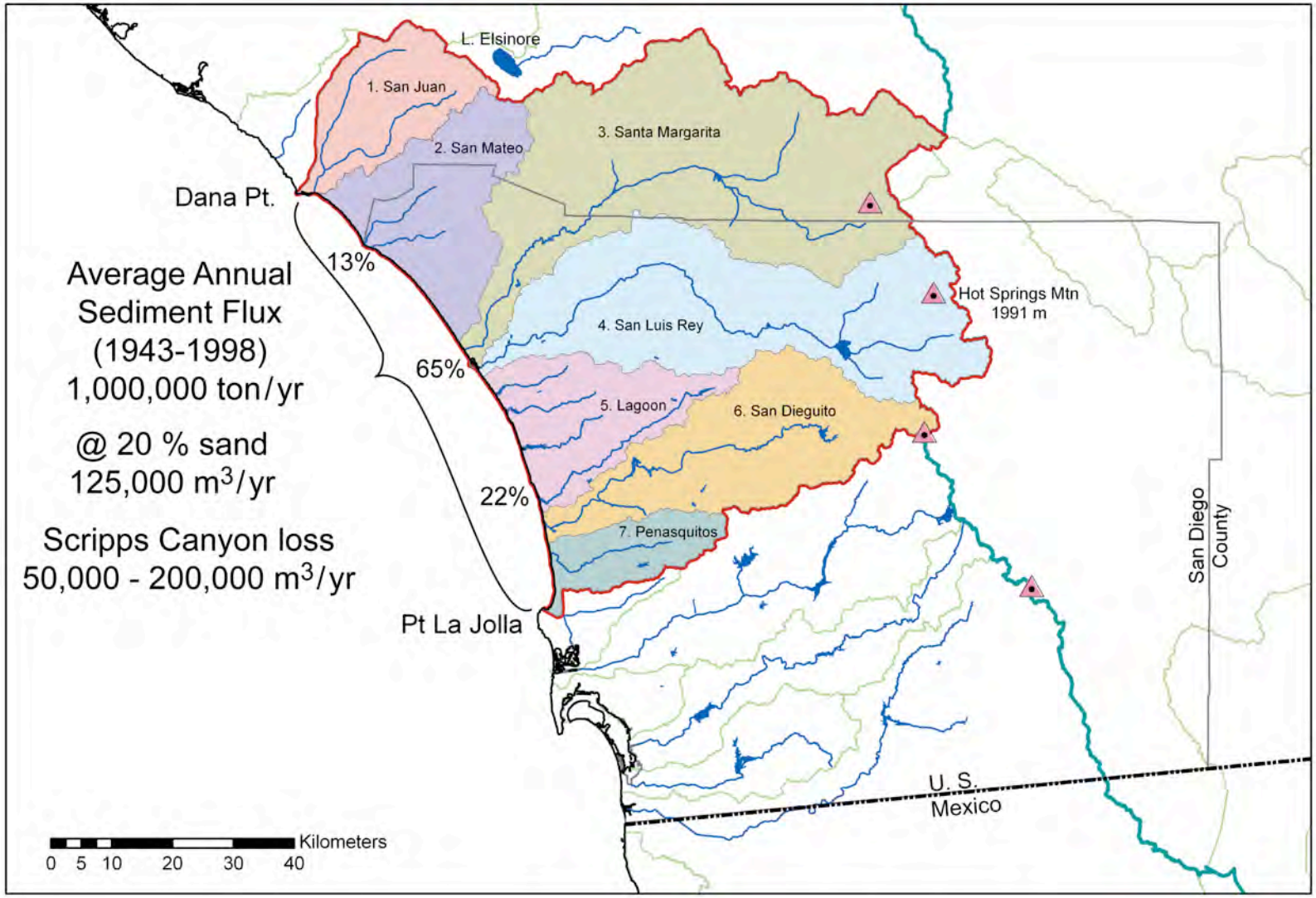
1. Rapid Sea Level Rise - Beach Loss and Accelerated Sea Cliff Retreat

2. Higher Avg. Temperatures - Increased demand for water results in decreased streamflow for sediment delivery to coast.

Beach Loss / Sea Cliff Retreat Due to Raised SL



Riverine Inputs of Coastal Sediment



Seven drainage basins of the Oceanside Littoral Cell.

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Current Work

Analysis of Erosional and Accretional Hotspots

Model Wave Energy Flux and Alongshore Sediment Transport

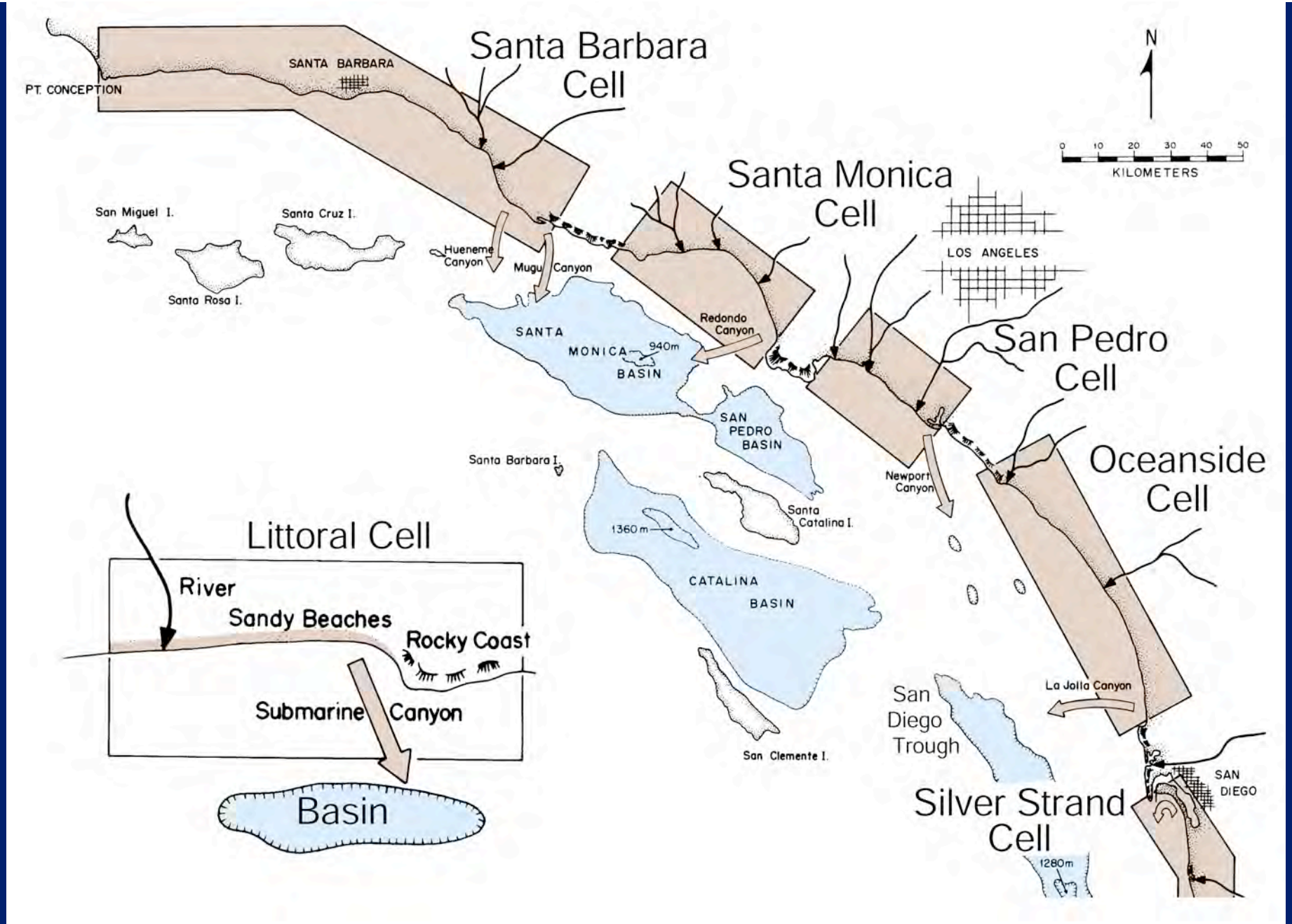
Past, Modern, and Projected Future Conditions

Modeling and Monitoring Sea Cliff Retreat

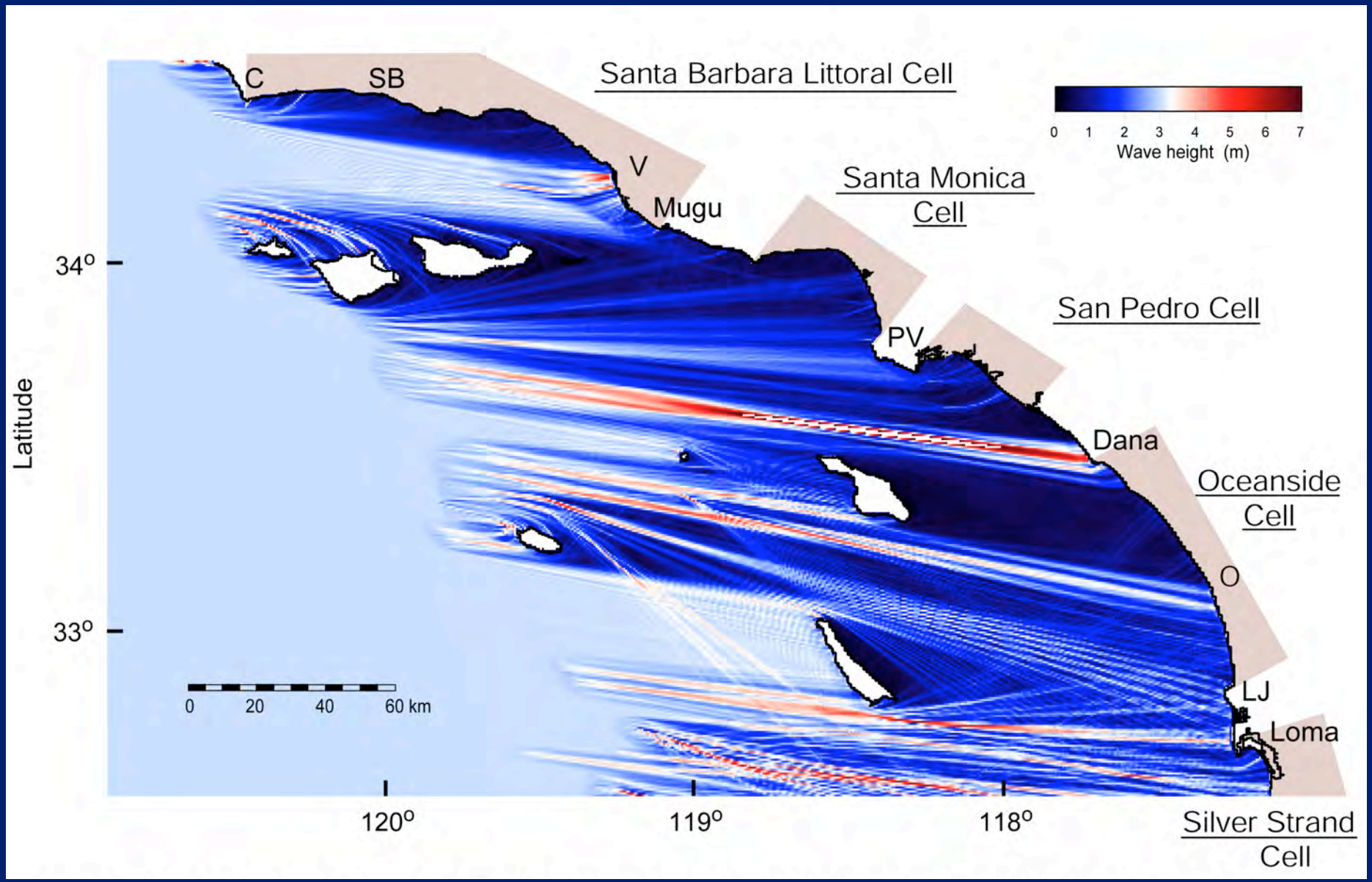
Identifying Processes

Applying Processes to Various Bedrock in Sea Cliffs

Link Modules Together Toward a General CEM



Littoral cells of the Southern California Bight [after Inman and Frautschy, 1965].


C
SB
Santa Barbara Littoral Cell
V
Mugu
Santa Monica Cell
San Pedro Cell
PV
Dana
Oceanside Cell
O
LJ
Loma
Silver Strand Cell
0 1 2 3 4 5 6 7
Wave height (m)
34°
33°
Latitude
0 20 40 60 km
120°
119°
118°

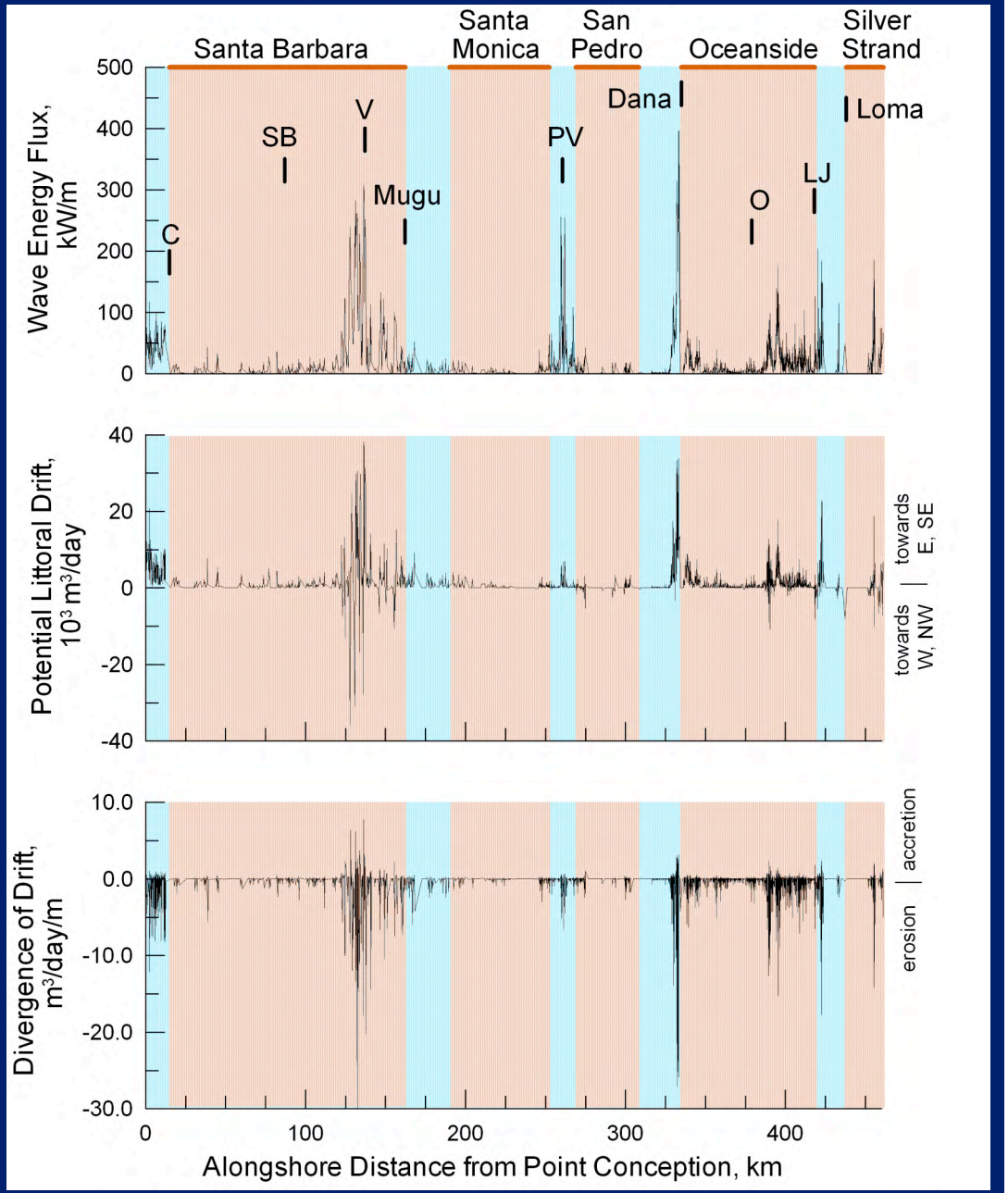
Identifying Erosional Hotspots

Calculate Wave Energy Flux from Refraction-Diffraction Modeling

Determine Potential Alongshore Drift

Calculate Spatial Derivative of Potential Alongshore Drift to

Determine Locations of Erosion or Accretion

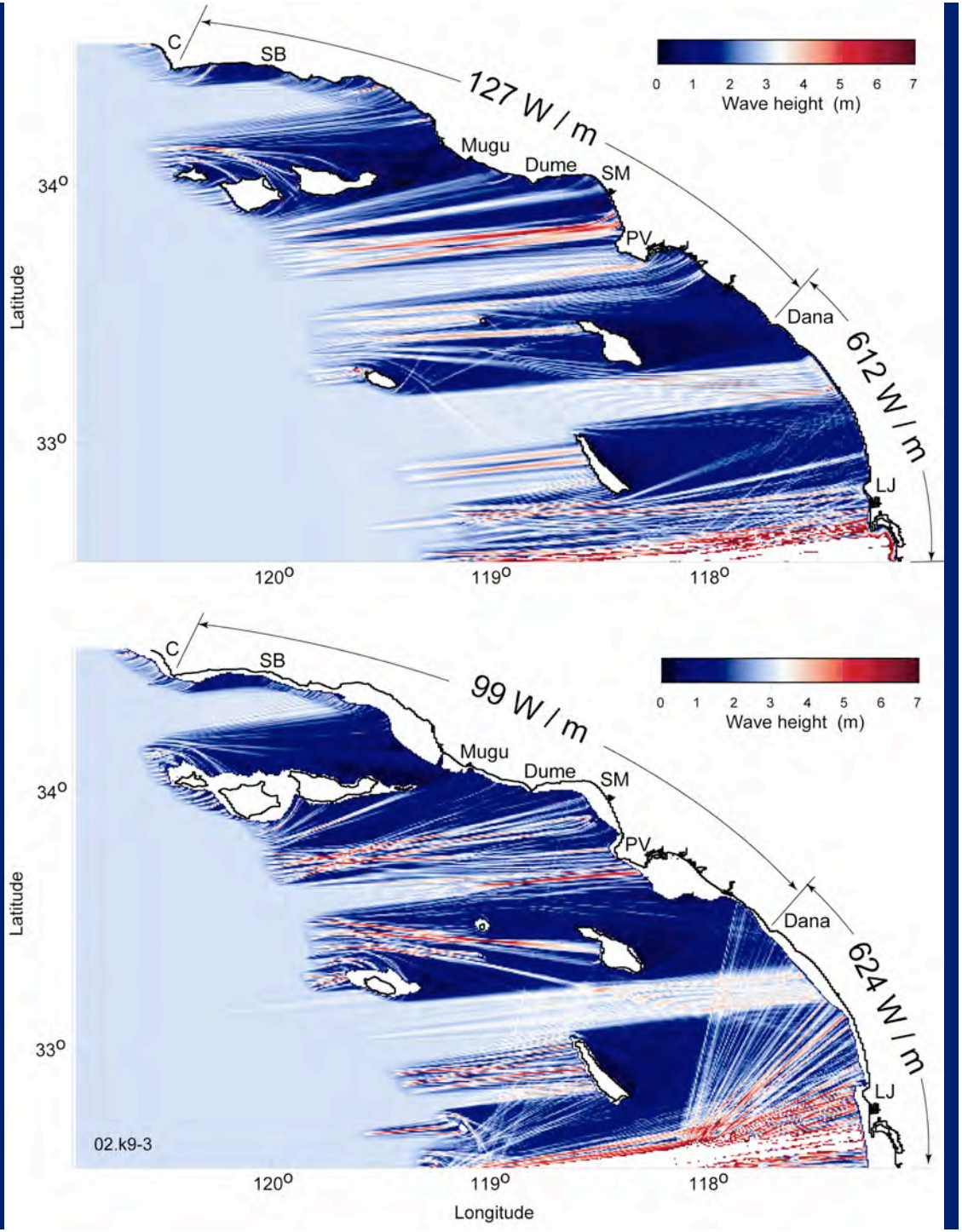


Applying Ref/Diff Model to Various Scenarios

Refraction/diffraction diagram for 15 sec, 3 m high waves from 260°

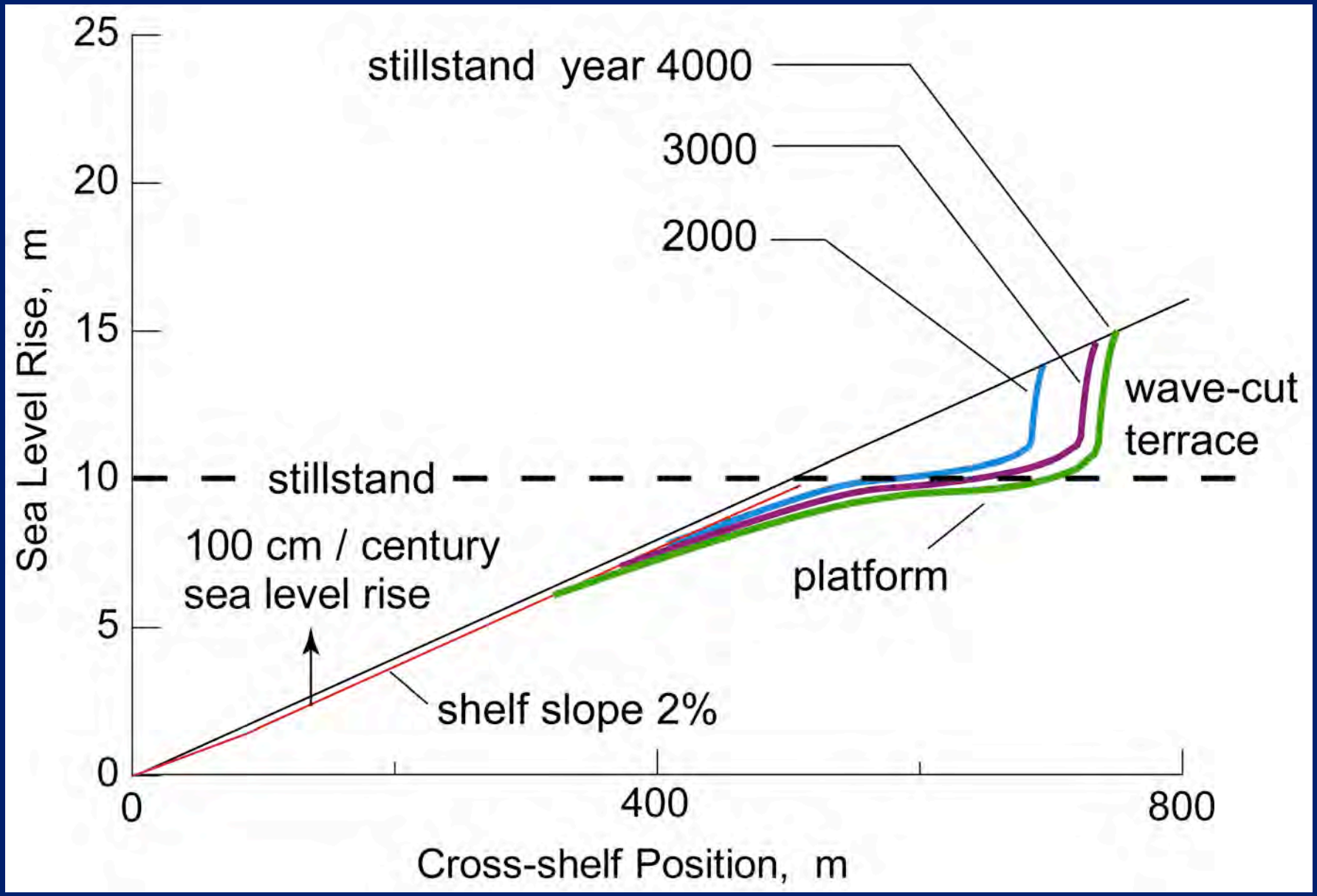
Present sea level

-54 m sea level

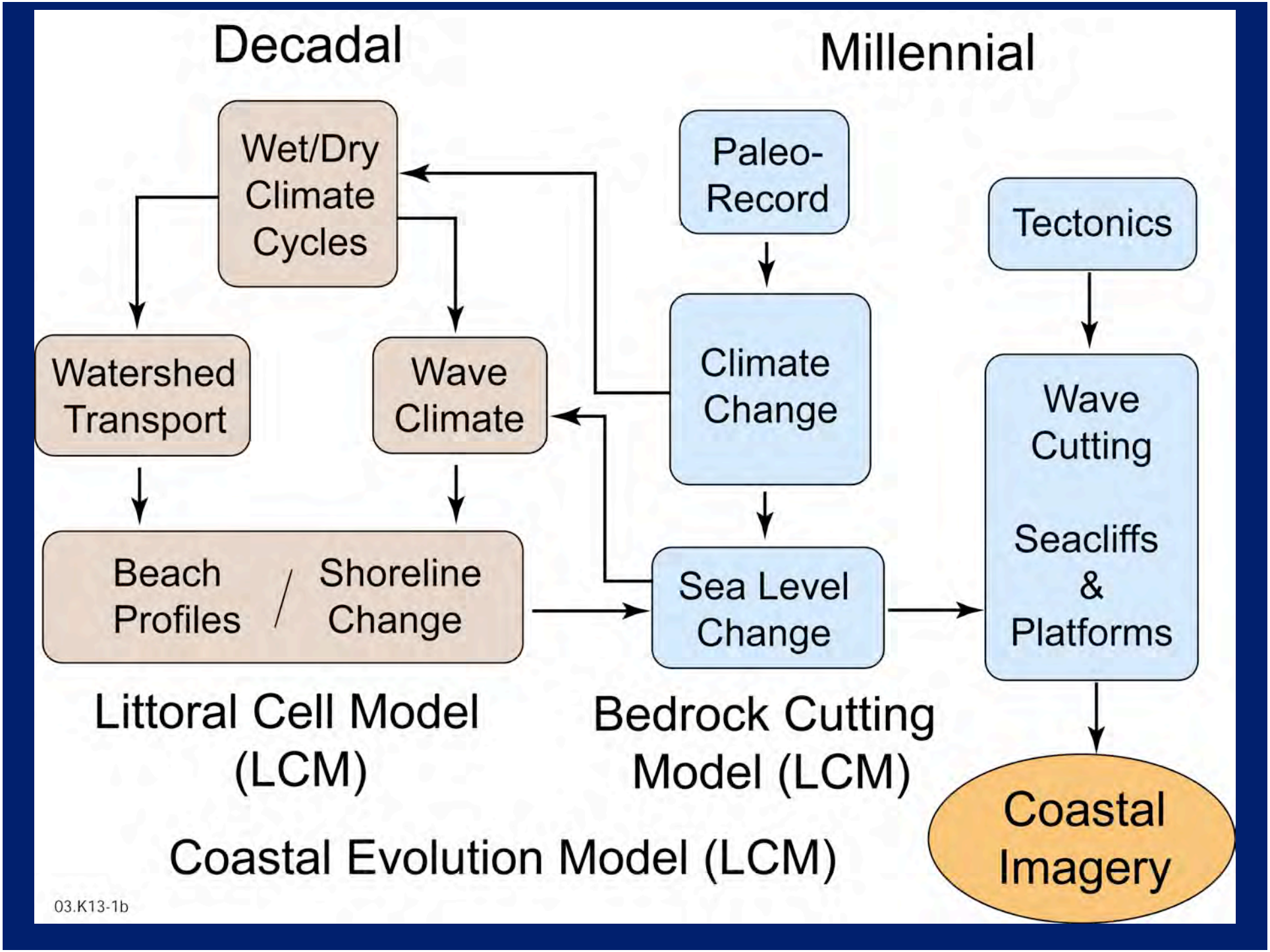


Exposed “Beach”

Solana Beach January 2003



Bedrock Cutting Model (BCM) showing change in initial shelf slope for transgression / stillstand scenario.


Decadal
Millennial
Wet/Dry Climate Cycles
Paleo-Record
Tectonics
Watershed Transport
Wave Climate
Climate Change
Wave Cutting
Seacliffs & Platforms
Beach Profiles
Shoreline Change
Sea Level Change
Littoral Cell Model (LCM)
Bedrock Cutting Model (LCM)
Coastal Imagery
Coastal Evolution Model (LCM)
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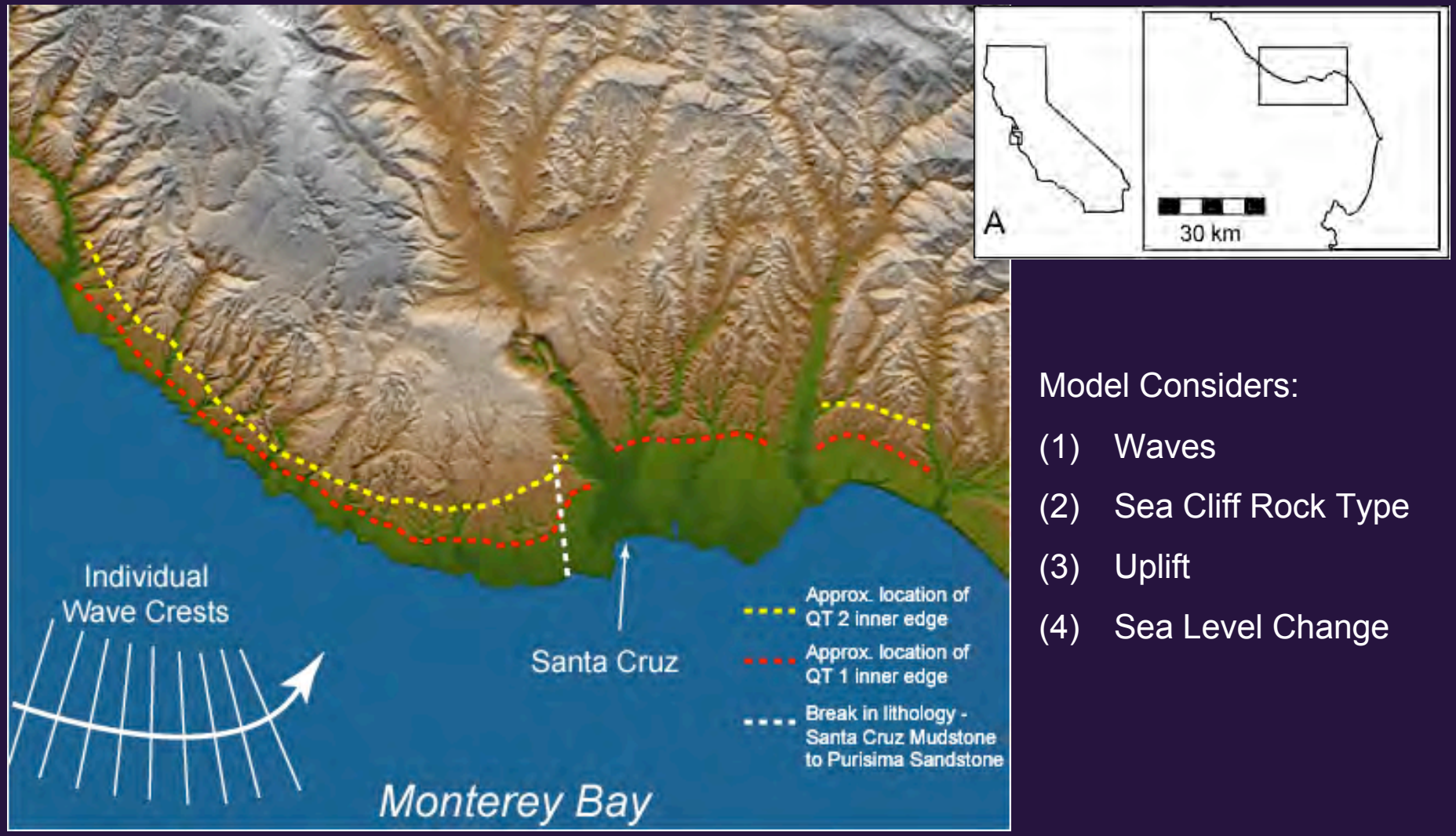
Modeling the Long Term Evolution of the Coast



Model Considers:

(1) Waves

(2) Sea Cliff Rock Type

(3) Uplift

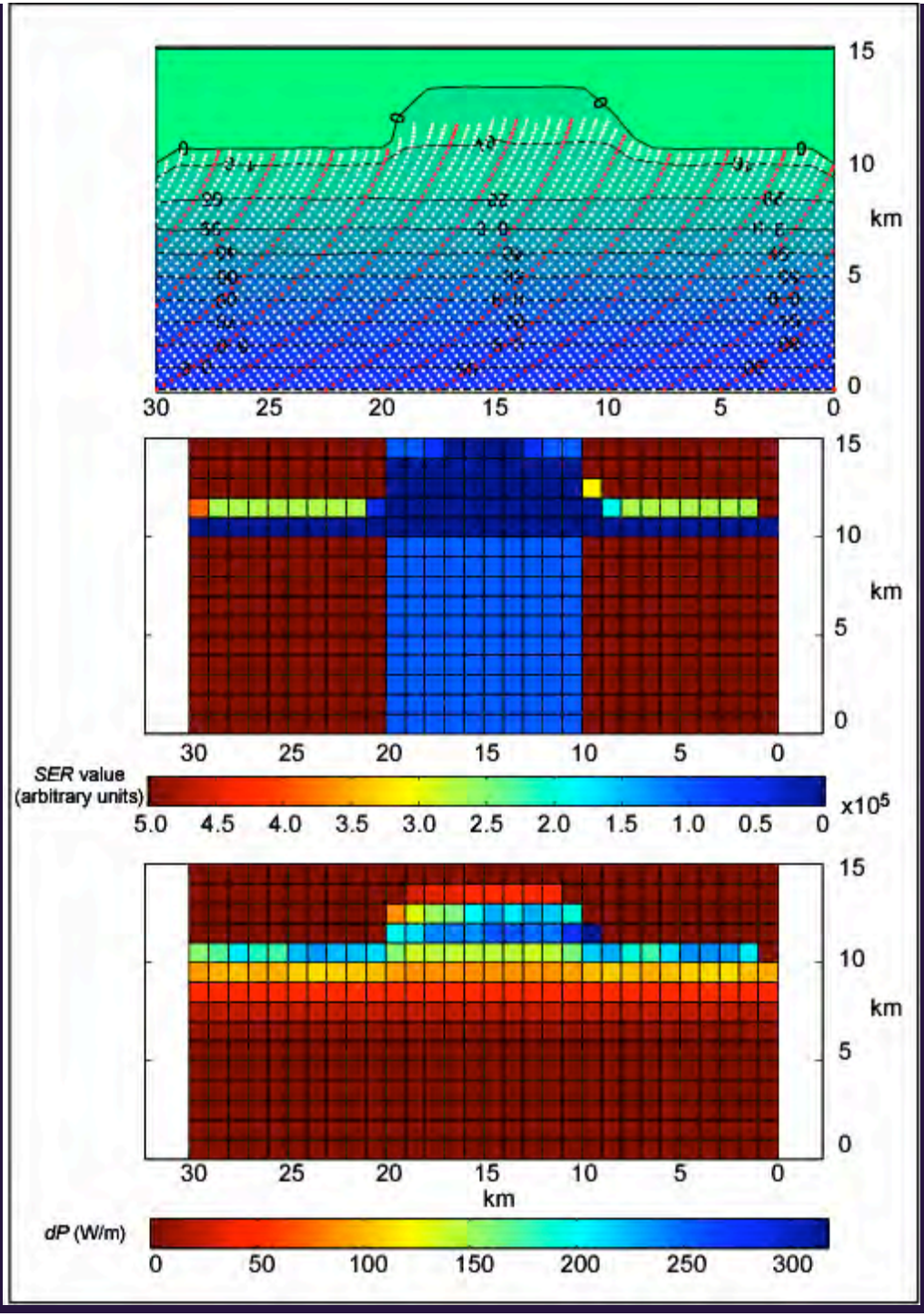
(4) Sea Level Change

Initial Modeling Results

Wave Rays
Evolving Bathymetry

Rock Fatigue
Sea Cliff Retreat

Wave Energy Dissipation
Submarine Erosion




Pressing Concern